NASA TECHNICAL MEMORANDUM

NASA TM X-64537

JOINT ASSESSMENT AND MANAGEMENT EVALUATION SYSTEM

By Preston T. Farish and Richard J. Stein
Systems Safety and Manned Flight Awareness Office

July 1, 1971

NASA

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. TMX-64537	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Joint Assessment and Management Evaluation System		5. REPORT DATE July 1, 1971 6. PERFORMING ORGANIZATION CODE
7. AUTHOR (S) Preston T. Farish and Richard J. Stein		8. PERFORMING ORGANIZATION REPORT #
9. PERFORMING ORGANIZATION NAME AND ADDRESS George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama 35812		10. WORK UNIT NO. 11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS National Aeronautics and Space Administration Washington, D. C. 20546		13. TYPE OF REPORT & PERIOD COVERED Technical Memorandum 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

Prepared by Systems Safety and Manned Flight Awareness Office

16. ABSTRACT

An optimized task arrangement to integrate development functions into an organizational structure is presented in this report.

17. KEY WORDS	18. DISTRIBUTION STATEMENT General Distribution Richard J. Stein

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	39	3.00

MSFC - Form 3292 (May 1969)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

TECHNICAL MEMORANDUM X-64537

JOINT ASSESSMENT AND MANAGEMENT EVALUATION SYSTEM

SUMMARY

This proposed management system embodies the principles of centralized control, and information traceability and flow throughout the technical and business disciplines of the development effort. The system identifies the total program effort in terms of functions to be performed. Each major function (level one) is numerically coded from 5. 0 to 1. 0 while each subsidiary activity bears its parent digit to which is sequentially added further digits pinpointing its exact location in the flow system. All documentation, of both technical and business origins, also bears this same numerical designation identifying its precise relationship to the flow system. The responsible individuals in government and industry are identified for each function or hardware at each level.

The system has been conceived as a closed loop system to accommodate contingencies. These are treated as a major function and given the numerical numbers 6, 7, and 8. This "go-no-go" loop underlines the requirement to encourage the design engineer, as well as the operator, to consider contingency alternates; thus, removing, or at least cushioning, the so-called "fire brigade" approach to problem solving.

To reach a reasonable accommodation with fiscal funding as practiced by the U. S. Congress, a continuing three-level program (cost estimates and schedules) is suggested to maintain currency throughout the program life cycle and to insure rapid response to program fluctuations with minimum impact upon development progress.

It must be recognized that there is no management or organization system that can compensate for first rate personnel. A system can offer novel accommodations for information flow to facilitate direction and control, but decisionmaking leading to direction and control can be made only by personnel exercising their intelligence based upon information at hand.

INTRODUCTION

Development programs subsisting upon federal funds face searching appraisals during the coming decade. This is prompted in the most part by the increasing demands upon the tax dollar by widely diversified claimants.

Newly proposed programs will, therefore, face two major barriers to acceptance. First, the program itself will have to be supported by persuasive and convincing arguments of its technical and sociological worthiness as a national investment. Second, the program must demonstrate controllability as well as manageability to increase the probability of attaining program goals within the limitations imposed by initial estimates of resource requirements. In addition, the management organization must be sufficiently flexible to adjust to program schedules and objectives within the variations of the capricious incremental funding system. Operating a technologically viable program within the limitations and fluctuations imposed by the incremental funding system is perhaps the greatest future challenge faced by the program managers. It appears that to successfully cope with contingencies as well as with basic program progress, it will be vital for allocated resources to be closely monitored and controlled, indicating that technical operations must be tightly supervised and few, if any, misdirections allowed to pass the point of significant commitment. In this context, therefore, it follows that the development effort must come under close scrutiny not only from the acceptability of a posed solution to problems encountered, but also from the point of view of resource commitments.

The manager of future programs will be placed under even more demanding stresses than in the past. He will face close scrutiny to determine if he is selecting the least costly solution to problems, minimizing changes, crystallizing designs at reasonable and practicable stages of development, and maintaining the program momentum within the variations of costs estimated at the outset of the program, in addition to closely maintaining the projected calendaric schedules. Thus, every decision will have to be integrated, considered, and promulgated within the overall guidelines of achieving program aims that constituted the initial goals, as initially approved, and at a cost which adds very little to the total cost estimated at the outset of the program.

In devising a management and organizational system that will meet or at least accommodate the majority of these projected probabilities faced by the manager of future programs, the need for a system that is responsive to the dynamics of real-time problem solving immediately suggests itself. Thus there is a very real need for a system that allows adequate "trade-off" to explore alternate approaches to problem solving as well as to objectively isolate problems expeditiously. Rationalizing management operations in this manner places the manager in the position to assess various problem solutions in terms of total commitment, while keeping the objectives of his program, project, or task constantly in mind. Such an "attitude-approach" syndrome should facilitate a broad-view philosophy enabling the avoidance of over-commitment in relatively unimportant situations.

It is submitted that the management challenge posed by the current climate under which public programs are initiated and supported may be met in large measure by adopting functional flow concepts.

THE MANAGEMENT PROCESS

The basic thesis here is that the management process is sensitive to work assigned which may, for the purposes of this discussion, be defined as goals, missions, programs, projects, and/or tasks. When considered in the context of functional management, these familiar terms serve to index the management process that pervades the various levels of authority and to illustrate their functional interrelationships. The following definitions and brief discussions for these terms should serve to illustrate their usage in this paper:

The Goal — A statement of the overall objective which is to be accomplished. In terms of government operations (Fig. 1), the goal is a statement of the ultimate aim of the policies adopted by the administration and approved by the Congress through the process of making available the resources by which the policies can be implemented.

The Mission — A statement, in very broad and general terms, of how the goal or a portion of the goal is to be accomplished. As an oversimplification, perhaps a mission merely states what will be done.

The Program — A definitized statement of the comprehensive plans and methods to be used in accomplishing the mission.

The Project — A specification of one or more segments of the program whose approximate objectives are assigned within the framework of the program's mission. The specification details the technical hardware (its design, manufacture, operations, servicing, etc.) required to accomplish the limited objectives assigned.

The Task — A work segment of one or more elements constrained by project objectives and associated with work stated by project requirements imposed on hardware and software components, subsystems, and systems.

Once the goal and mission have been defined, it is common practice to devise a work breakdown structure preparatory to parceling out contributory programs to operating segments of the parent organization. A structure was prepared for the Apollo Program (Fig. 2). However, this type of gross planning is not limited to space programs; it can be and is used in gross planning exercises for other government as well as nongovernment programs. The Appalachian Program (Fig. 3) lends itself to this type of gross divisions of contributory elements to operating groups.

The functional flow system which is proposed divides the program into functional segments instead of structural or mechanical divisions. It is designed to describe top level operations conducted throughout the program's life span, inclusive of planning, design, development, and operations. The example selected tailors life functions to the unique characteristics of the development in its anticipated life cycle.

The functional breakdown may be developed in considerable depth prior to a detailed allocation of specific pieces of equipment. For example, if a rocket booster is required, we know that tanks, engines, plumbing, pipes, and valves will be needed without reference to specific engines, specific valves, or specific pumps. Further, the capacity for work required of the pumps, valves, engines, etc., can be definitized rather early. This capability facilitates a more precise estimate of resources at various stages of program evolution especially in identifying and isolating areas in which varying degrees of research and development will be necessary. Areas of which little or no state-of-the-art consistent with requirements exists should become readily apparent, enabling an assessment of confidence in estimates. On the other hand predetermined alternate approaches to potential problems, with estimates of required resources, will greatly simplify the management decisionmaking process when the foreseen problem materializes. Armed with such managerial weapons, the manager can then face with confidence the most searching inquisition into his stewardship of government sponsored programs.

Taking the goal, mission, etc., as representative of a tier or level of management operations, the process of definitization becomes more precise; documents proceed from the very general policy statements to directives, to detailed specifications, drawings, and procedures; while organization and management functions become exacting in operating more precise jobs of discrete technological and business disciplines with more exact auditing methods.

These are translated through the functional structure into end-item oriented organization and management operations. Without dealing in depth with the problems incumbent upon and inherent in programs defined in such terms, alternate approaches to the problem of organization and management in complex developments through a functional work breakdown approach offer some interesting alternatives to the more traditional organization and management concepts.

PHASED PROGRAM PLANNING

The functional flow concept can be mated quite easily to the intent of phased program planning. Each phase can be defined in terms of the discrete functions that must be completed within the framework of phase definition. These terms can be cited with minimal information regarding the firm and discrete requirements to be met by the functions cited — those can be added as concepts crystalize and hard requirements begin to surface. Within the framework of functional flow, the degree of commonality and comprehensive fruition of all requirements necessary to total program progress will thus be visible. By defining "what should be" as functions in the various program phases, a contractor's ability and progress can be easily measured by a review of "what is." The differential will reveal that either the definition of "should be" is too stringent or unrealistic, or that a deficiency in contractor performance exists. The application of functional flow concepts to phased program planning will augment the former by facilitating management control through the descriptive facility of generalized "what should be" in specifications, test requirements, procedures drawings, reports, facilities, transportation, handling, and ground support equipment maintenance and repair.

This type of layout will also ease the problem of control of work within a phase of the program, assuring that all phase elements are carried forward in a balanced fashion consistent with desired completeness at phase termination.

MANAGEMENT OPERATIONS ADAPTED TO FUNCTIONAL FLOW

Any management system must accommodate itself to the classic role of management, which is described as consisting of five discrete jobs: planning, organizing, assembling resources, directing, and controlling. Through these processes, management has operated the readily discernible functions of research and development, engineering, manufacturing, operations, and finance.

Inclusion of functional flow concepts into classic management operations should serve to further delineate adaptability of the system. The system functionalizes management operations by categorizing them relative to the functions to be performed throughout the life of the program. The concept of planning has been moved from a staff (management) function and located as one of the five major functional operations (see Shuttle Program example). This move means planning an operation to which the authority of controlling, assembling resources, monitoring, and organizing has been added. In short, the planning organization is the single control point at the manager's disposal for assessments to be made, directives to be issued, and budgets to be assembled. It is through this operational element that continuity of technical effort, even-handed treatment of problems, and allocations of technical skills for problem solving emanates. The disciplines of configuration management (knowledge of current configuration), systems engineering (compatible "inter" and "intra" design and development approaches), systems assurance, test and operations management are allied to functions, such as development operations, ground operations, flight operations, or post-flight operations. The comprehensive functionality of these disciplines tends to insure maintenance of expertise and knowledge gained of early conceptual phases being carried forward through the program's life cycle.

Diffusion of management operations throughout a series of staff offices with varying degrees of authority and attention, complicated by the multiplicity of individuals reporting to the manager, is avoided. The manager receiving a planning document from his functional operations office can be assured that all of the modifiers, such as technical and business problems, have been incorporated and that other line elements have, as a matter of course, reviewed and contributed to appropriate elements of the plan. Bringing real-world conditions into a classic staff function should tend to reduce or eliminate misunderstandings with classic operational elements as the problems faced by both become a matter of mutual concern. In addition, by engaging in day-to-day problem solving, the planners will know the current program status, and time formerly required to "get up to date" will be reduced or eliminated, thus, speeding up the management process and eliminating redundancy. Thus incorporation of management operations into functional flow appears to offer marked advantages for the managerial process.

To illustrate a functional flow system, the Shuttle Program, an integral part of the Space Station effort, has been selected. It should be borne in mind that if the Space Station program were selected, the Shuttle system would show up in the lower tiers of the functional flow system. In terms of our previously described divisions, the Shuttle Program would be considered as the Shuttle project with a basic logistics support mission while the Space Station would be considered as the program. The illustration, then, is not representative of a complete program for a space system, but it is believed to adequately demonstrate the idea.

Throughout the functional flow system, it should be noted that every effort has been made to integrate both business and technical disciplines with classic management processes at appropriate levels of decisionmaking (goals, programs, projects, and tasks) while retaining within the functional flow system the classic management functions of research and development, engineering, manufacturing operations, and finance.

APPLICATION TO THE SHUTTLE PROGRAM

This discussion illustrates functional flow using the Shuttle Program as a model. From the foregoing paragraphs, the general criteria for a functional flow management can be restated as follows:

1. Identification and control of materials (product), cost, personnel, and schedules that relate systems requirements to a single baseline.

2. Access, visibility, and communications across the program levels and throughout the program life cycle.

3. Contingency system, "go-no-go" at all levels to accommodate the decisionmaking process as a day-to-day routine program.

Specifically, we may word the requirements for a theoretical system as:

1. It must provide for stringent technical control procedures

2. It must provide for stringent resource control procedures.

3. It must minimize documentation requirements.

4. It must provide for schedule control and the proper level of program backup planning to cover high risk areas throughout the total program cycle (keyed to technical and resource indices).

5. It must provide management visibility throughout the total program, at all levels of activity, from the designer and man on the floor to top management.

6. It must provide contingencies (closed loop servo system).

7. It must respond to fiscal year fluctuations with minimum impact upon the overall schedule.

Resources Management

The technical and resources management system would be improved by increasing visibility and insuring traceability of resources while providing feedback for planning to fully integrate management of business affairs and management of technical affairs. A single function vested with full authority to develop solutions to problems encountered and to control the rate of expenditure of resources as well as the commitment of resources in specific areas of activity is desirable. To allow sufficient flexibility to maneuver within the allocations assigned to individual functional managers, the same method as employed by Congress to executive branch allocations may be used. Thus, guidelines for requested allocations forwarded to the managers form a basic reference for the manager in planning his scheduled work and formulating "hard" requests. Sanitizing the requests and collating them form the basis for allocations from Congress. Approving and enabling authorities to have grants provide for percentages overruns which should be passed down, or prorated on a risk assessment basis, through the system to the manager. Thus, each manager can adjust his planned effort within the authorized limits conditioned by the knowledge that a reserve is available for unforeseen contingencies directly identified by and related to the functional flow index number. It is believed that the system detailed herein will serve as the management and organizational vehicle geared to accomplish the requirements enumerated above. The system essentially identifies program elements as critical management points and provisions for monitoring and controlling cost, schedules, technical progress, and documentation of the overall program.

It is with these factors in mind that this proposed system of organization may be illustrated by use of the Shuttle Program. Since the program encompasses a joint venture between NASA and private industry, it has been designated as a joint assessment and management evaluation system, implying the use of a baseline by all concerned parties.

The contribution of the management system to the decisionmaking process is vital to its success. Information and data upon which management can act, and act quickly and decisively, must be immediately available at the critical time. To provide for these desirable conditions, the system described herein encompasses the following capabilities:

1. Identifies a focal point for the control and decisionmaking process.

2. Combines the elements of management with technical control to insure compatible progress toward program goals.

3. Identifies program data with its functional element to substantiate the initiation, adjustment, and reallocation of program resources.

4. Initiates a single management system that is adapted to both the development and operational phases with minimal confusion and lost momentum during the transitional phases of the program life; allowing preplanned personal adjustments at critical phases while maintaining adequate staffing of key personnel.

5. Permits preplanned and controlled buildup or reduction of contractor support to avoid difficult and unwieldy dislocations during transitional periods of the program.

Program Elements

The basic scheme identifies program elements, in a sequential manner from the mission definition through the more detailed aspects of the work, to be accomplished within the overall tasks enumerated. The systematic indexing system is defined as follows (Fig. 4):

1.0 Post Flight Operations — Interval from landing until loading for transportation to launch site, includes checkout, inspection, repair, refurbishment, maintenance, spare parts, and transportation to the launch site.

2.0 Flight Operations — Interval from first movement on launcher until landing, includes propulsion, guidance, separation, data link, orbital insertion, docking, on station, separation, checkout, deorbiting, maneuver, reentry, fly-back, and landing.

2.1 Boost Phase — Booster operation from first movement to burnout. Minimum specified impulse under all environmental conditions, guidance and control requirement, contingency measures for flight abort and crew escape.

2.2 Separation — Positive separation, retropropulsion ignition and operation, rate of separation movement, roll program.

2.3 Booster Return — Flight stabilization, controlled fly-back to ground base, and landing (technique to be determined).

2.3.1 Maneuvers — Includes all maneuvers (powered or nonpowered) to which the booster will be subject subsequent to assuming the attitude for the flight to ground base.

2.3.2 Fly-Back — Operations connected with flying the booster back to the ground base, navigation, control, engine operation, attitude and altitude control, air-ground communications, prelanding checkout, provisions for crew emergency escape and emergency landing must be considered.

2.3.3 Landing — Operations initiated upon entering the landing phase or pattern, approach, instrument or visual landing techniques, touchdown, roll down, or stop motion on ground or water (techniques to be determined), power shutdown, ground support including emergency support.

2.4 Logistic Support Mission — Operations of the orbiter in its supporting role as a shuttle to the space station.

2.4.1 Rendezvous Operations — Includes operations of the orbiter after booster separation, engine ignition, powered flight, burnout, orbital insertion, parking, and transfer to rendezvous orbit. Provisions for emergency abort or corrective action must be included for crew safety.

2.4.2 Orbital Operations — Includes operations upon entering the space station rendezvous mode, approach, docking, "on-station" operations, checkout, separations, assume deorbit attitude, and ground-orbiter, space-station-orbiter communications.

2.4.3 Orbital Return — Includes operations of deorbiting, entry, flyback, landing, communications, navigation, and emergency provisions for crew safety, e.g. alternate or emergency landing bases or modes.

2.5 General Support Mission — Operations of the orbiter in diverse earth-orbital operations, delivering or servicing orbiting satellites or payloads in earth orbits.

3.0 Ground Operations — Interval from shuttle hardwares (GSE and flight) loading for transportation to launch site until first movement on launcher, includes inspections, assembly, checkout, quality control, refurbishment, repair, fueling, life support, systems checkout and verification, payload integration, launch readiness, ignition, hold down, release, and first movement on pad.

4.0 Development Operations — Interval from designer initiation until loading of shuttle hardware (Flight and GSE) for transportation to launch site, includes design, testing, fabrication, manufacture, inspection, checkout, and assembly.

5.0 Planning and Missions Analysis — Includes the functions that must be accomplished to design initiation, including mission designation, performance requirements, flight profiles, hardware constraints, flight performance analysis, redesign verification, environmental levels for life support, payload definitions, logistic requirements, maintainability requirements to design initiation, and resource estimations and allocations.

6.0 Corrective Action — Alternate actions executed to assure primary or secondary mission accomplishment.

7.0 Abort — Any action initiated as a result of a noncorrectable malfunction that causes mission cancellation.

8.0 Maintenance — Actions required to keep or return the flight and ground support equipment in an as-designed operational condition.

The five divisions of the Shuttle Program (Fig. 5) represent a major or primary level segmentation of the total effort from conception through operations. Planning and mission definition have been added as a primary or major function since it is conceived as a major management control function (as previously discussed), operating the resources field as well as within the technical field.

Thus, each of the functions from 1.0 through 4.0 would be operated from a single set of ground rules (coordinated through function 5.0); changes in either of the functions would automatically be reviewed for adjustments or changes to the others (Fig. 6). Then, single point location would lend not only total program continuity but also tighter redundancy controls. An added bonus lies in the build-up of experience on the part of the individuals working within the functions, and their experience will be of considerable value in later program stages. Personnel shifts may also be preplanned and implemented as a part of program management as emphasis shifts to more advanced aspects of the development. Thus, a fairly constant level of personnel involvement will be possible, obviating severe fluctuations of employment, with the attendant confusion and personal impacts accompanying force reductions as the work moves forward.

In addition, three other operations — (6) corrective actions, (7) abort, and (8) maintenance — have been added to the functional flow as major decision points and reflect the underlying "go-no-go" philosophy of the system (Fig. 7).

This system philosophy is predicated upon the concept that upon completion of task in a sequence of interrelated tasks, the next in the sequence is undertaken. Obviously, as the more detailed work is undertaken within a task, parallelism of tasks will of necessity be encountered. In case the task has not been satisfactorily completed, it must be repeated by alternate approaches until success is finally achieved. Use of alternates in problem solution is the heart of the systems described, in that the system provides for contingency preplanning for all anticipated problems of both a fiscal and technical nature. This is indicated on the flow diagram by Tasks 6.0, 7.0, and 8.0; the indicated loop can be applied to any level of activity as indicated upon the sequential diagrams of lower tier activity.

A numerical indexing system (see Fig. 8) can be expanded ad infinitum under any of the major indices (Task 1.0 - 7.0). This reflects the flexibility of this system in that referral to any index number immediately fixes the phase of the program under discussion regardless of where or who performs the job; thus, it reduces confusion.

To illustrate the sequential nature of the system, Flight Operations (2.0) has been selected for delineation through several plateaus of effort. Figure 8 illustrates the second plateau of Flight Operations: Boost Phase, Separation, Booster Return (Fig. 9) followed by either a General Support Mission or a Logistics Support Mission (Fig. 8).

In turn, Task 2.4 (Fig. 10) has been detailed in Tasks 2.4.1 (Fig. 11), Task 2.4.2 and 2.4.3 (Figs. 12 and 13).

The "go-no-go" philosophy inherent in the Functional Flow System indicated in Figure 7 is developed to one more level of detail in the example cited (Fig. 14) of a problem developing in the Telemetry Monitor and Control (Functional Flow Number 2.4.1.2.1) system. The cascade of alternate approaches, initially limited to two, begins to multiply as the corrective action route is pursued to its ultimate conclusion. Implementation of corrective action allows the development process to continue, or conversely, an abort (no-go) requires initiation of a new start.

Documentation Requirements

As in all programs, the control documentation presents a problem. For this system three basic forms are shown whose format can be adopted to any of the functions shown: End Item Design Form (Fig. 15), Functional Analysis Form (Figs. 16 and 17), and Total Program Cost Evaluation (Fig. 18). The Functional Analysis Form has been completed to show the type of pertinent information that may be interrelated to the flow numbers (Fig. 17). Technical documentation such as schematics, flow diagrams, etc., forming the primitive basis for finalized drawings are part of the technical documentation which shall always be required for complex hardware design.

Control of documentation implies knowledge of the requirements, conditions, and status of documentation that is necessary to get the job done. Each phase of development and each phase of operations requires specific documentation. Whether the documentation consists of planning papers, schematics, design drawings, production drawings, specifications, or procedural manuals is incidental for our purposes. Thus, in order to be in a position to anticipate documentation requirements, as well as to be in a position to control it, it is suggested that the documentation be keyed to the Functional Flow numbers where it occurs under one of the five basic divisions of the program (Fig. 17). Thus, all planning documentation would begin with the digit 5, development with the digit 4, etc., followed by sufficient digits, reflective of the Functional Flow number to exactly pinpoint the documents area of applicability. Such a system will allow the following advantages: ease of identification, assurance of completeness, assurance of interface control, and identification of responsibilities for documentation. In addition, common formating throughout the program, regardless of what group or Center is responsible for the work, will reduce confusion, prevent duplication, reduce cost, accelerate scheduling, and should reduce the number of documents. Using a central maintenance and distribution point for all documents would further enhance control of the documentation throughout the program. The Functional Analysis Form is shown as an example of its use of Functional Flow numbers to key documentation to the function under anlaysis (Fig. 17). It is believed that such a system will materially assist in program control and cost savings.

The subjects (Engineering, Testing, Manufacturing, Finance and Operations) by which the management process (Planning, Organization, Assembling Resources, Directing and Controlling) are applied throughout the system in a continuous manner insure total continuity of effort (Fig. 18).

System Analysis

System analysis methodology provides for a single focal point for the initial identification, control, and accounting of system requirements.

The proposed methodology is the tool for systematically defining the hardware, procedural data, facilities, and personnel required to meet system objectives and for determining the total cost. The translation of system requirements into design requirements by means of the proposed techniques and procedures includes consideration of space launch vehicles, operational equipment, maintenance equipment, and facilities. Personnel requirements are being considered both qualitatively and quantitatively. Procedural data is defined in terms of technical manual requirements, specifications, and related data management material. The procedure proposed provides a single-source reference for the evaluation of design configuration on a total system basis through the entire life cycle, design, ground operation, flight operation, and post flight operation with systems safety an integral part of the total program effort.

Business Management

This proposed system can easily be extended into the business management area of operations. For example, the Functional Flow numbers can be applied quite logically to the Cost Accounting system which will permit a close control of allocations and expenditures and will serve as an indicator of the level of effort expended during discrete periods of the development cycle or program life. Such knowledge will not only greatly assist in developing incremental funding requests through government channels, but should alleviate conditions leading to overrun situations. It would also identify underruns as well, thereby enabling management to deobligate and reprogram funds for more urgent or critical needs. In addition, the interplay of both the technical activity and business management within the framework of the common code indexing system proposed herein allows for close control of manpower allocations which will allow controlled buildups in early program phases and will cushion the adverse impacts of personnel reductions during the later program phases (Fig. 19) .

Additionally, costs of changes or change orders keyed to Functional Flow numbers for which past allocations are identified will easily permit assessment of the legitimacy of the added funding and/or resources claimed by the contractor for the additional work. Such instant information should greatly assist in facilitating the completion and closeout of change actions.

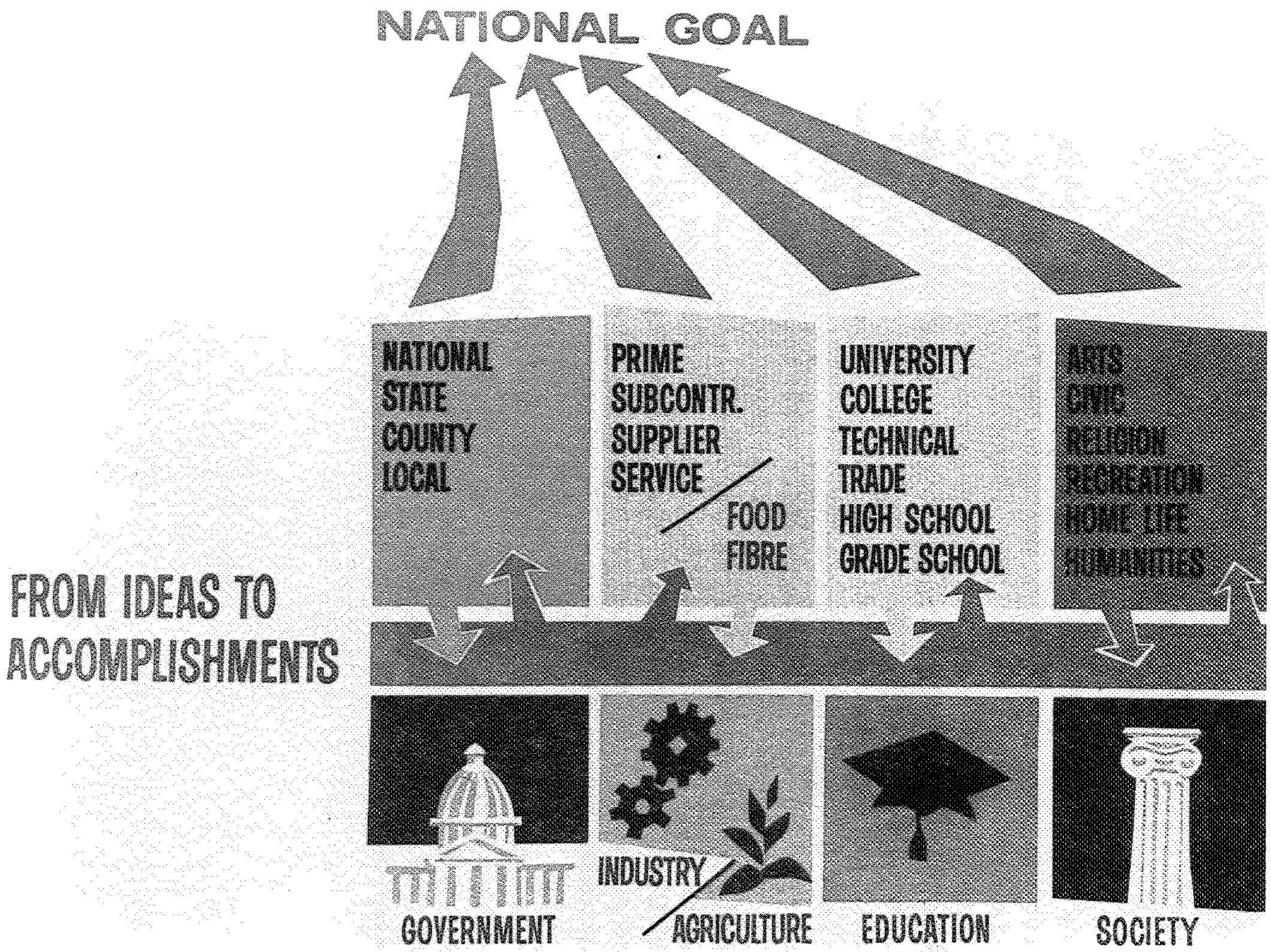

Figure 1. National goals.

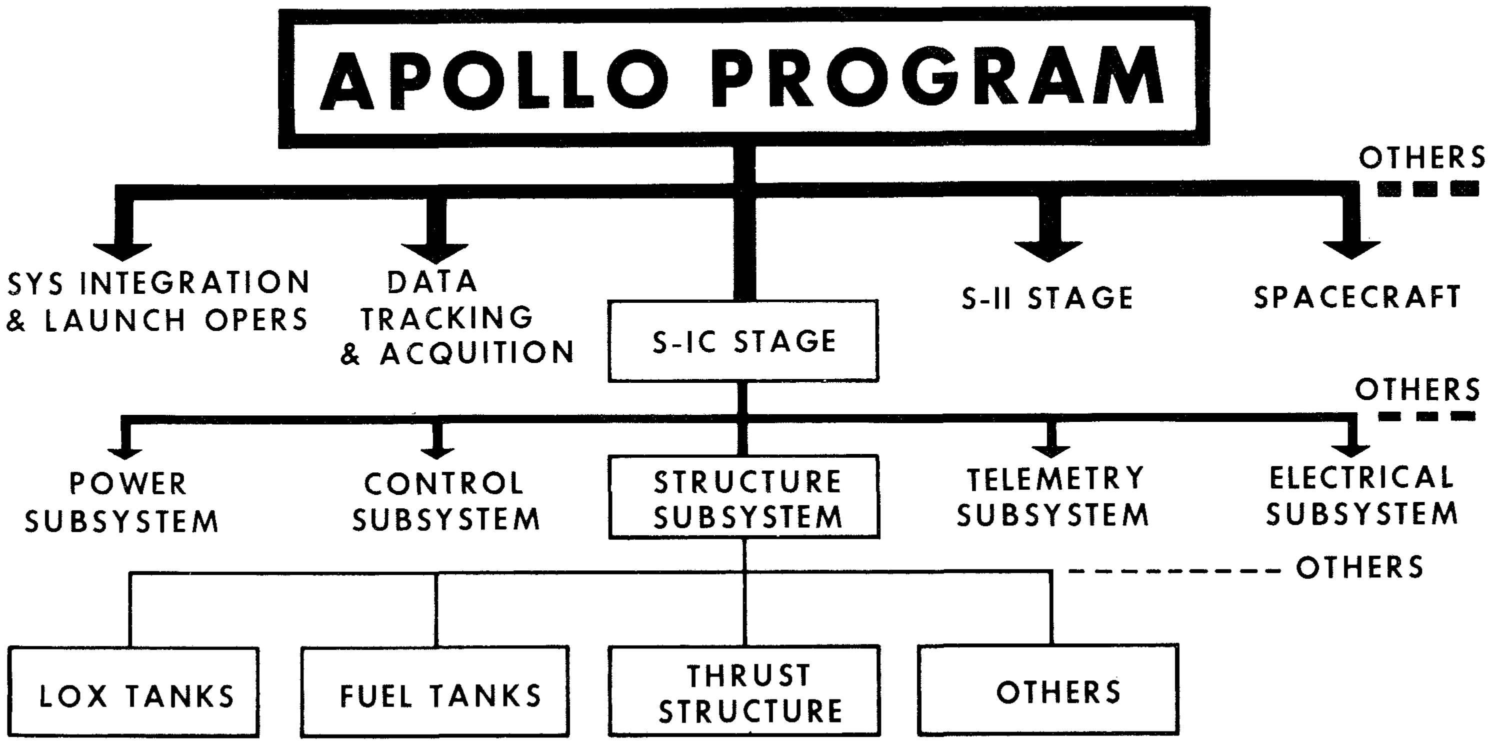

Figure 2. Work breakdown structure - Apollo Program.

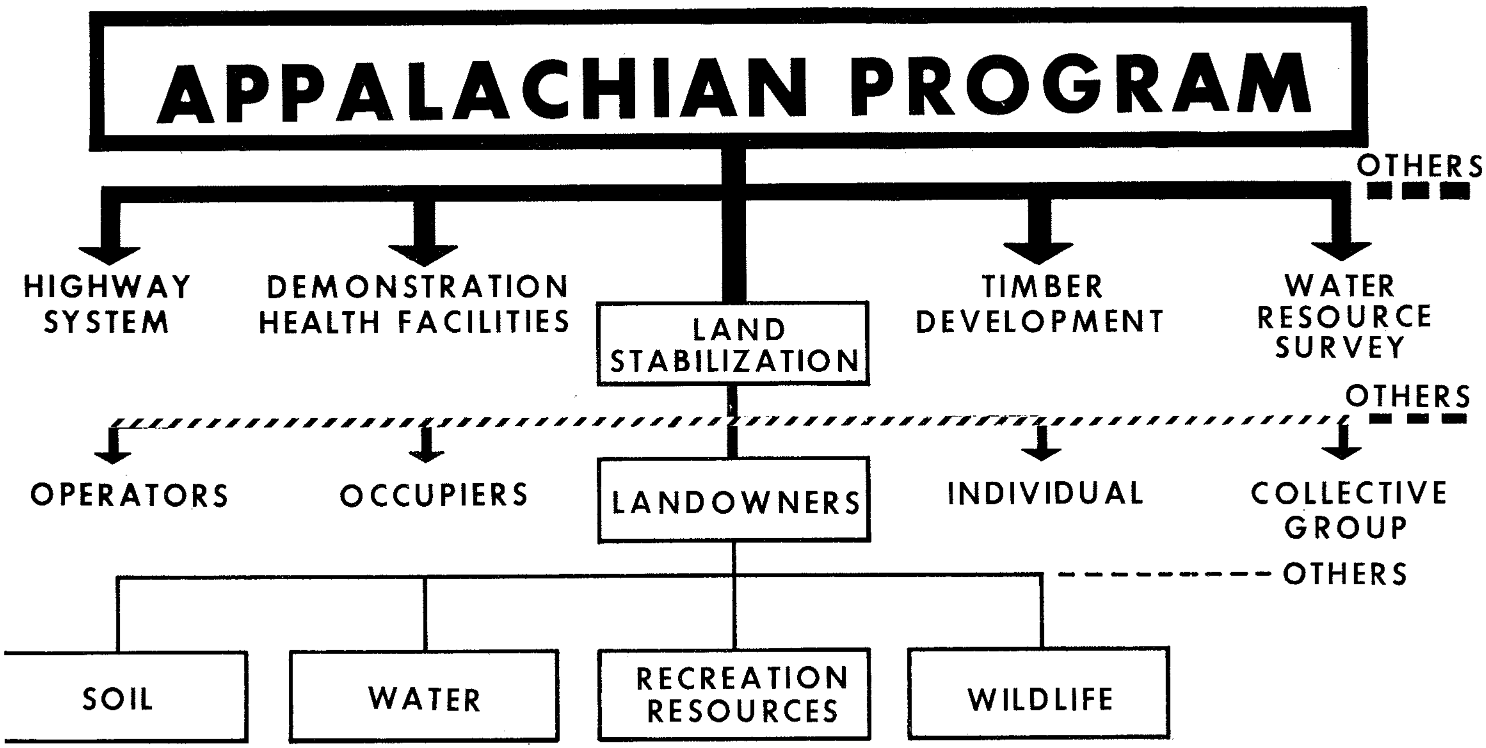

Figure 3. Work breakdown structure - Appalachian Program.

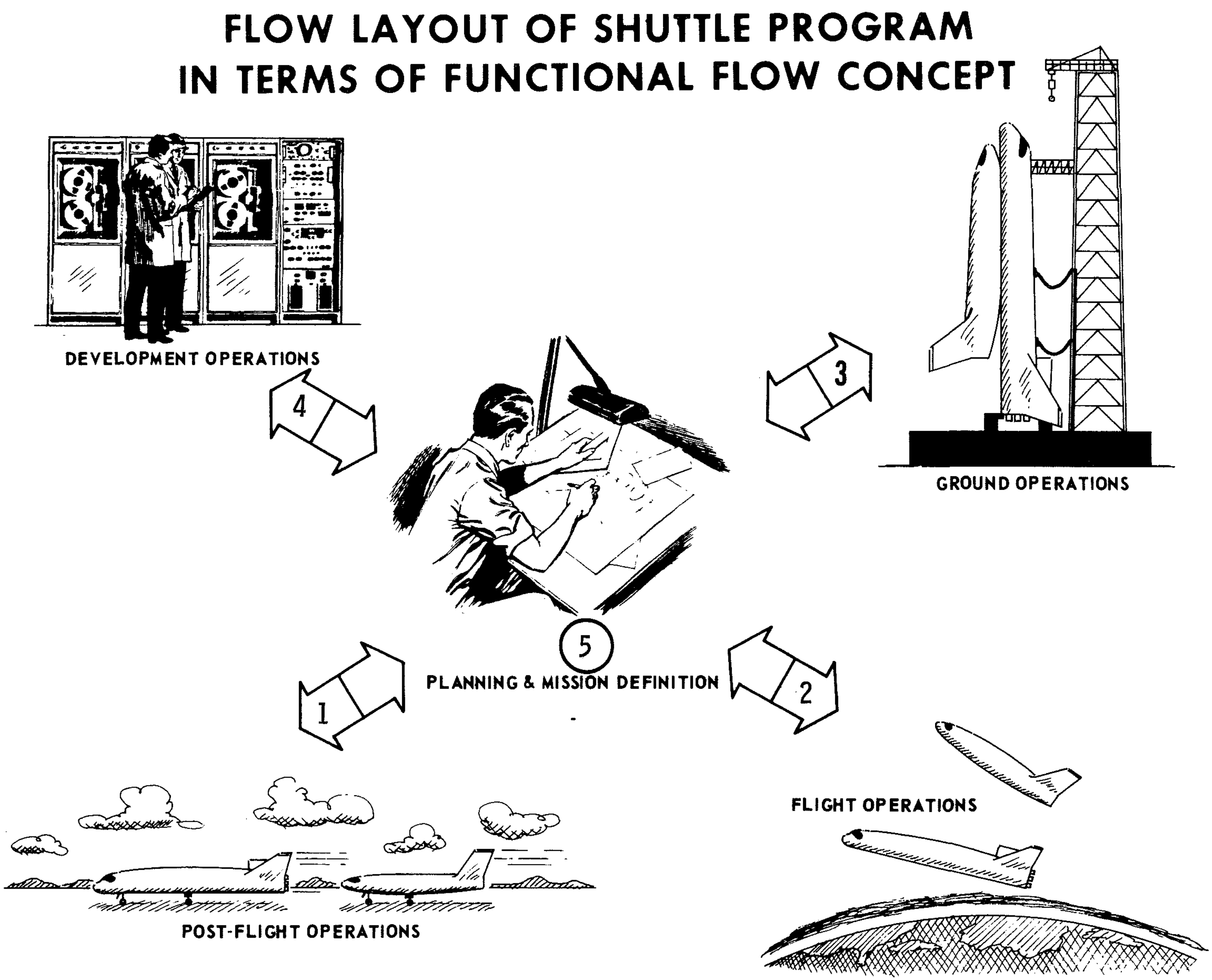

Figure 4. Schematic functional flow.

Figure 5. Basic division of Shuttle Program Elements

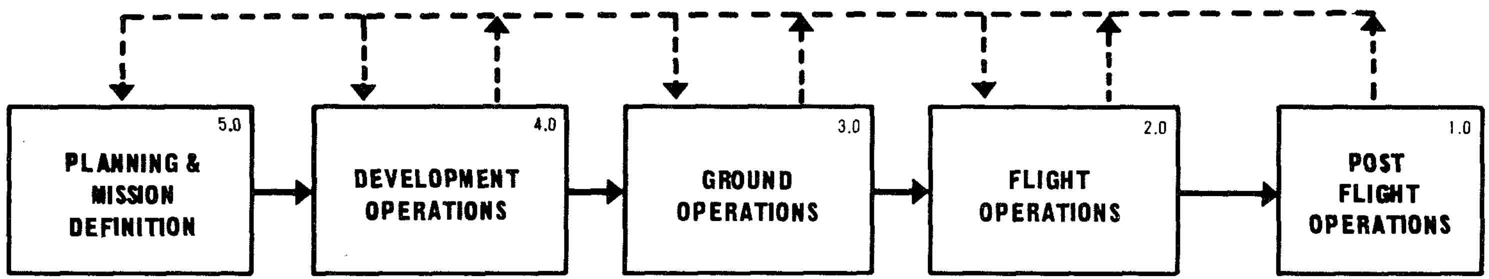

Figure 6. Information feedback

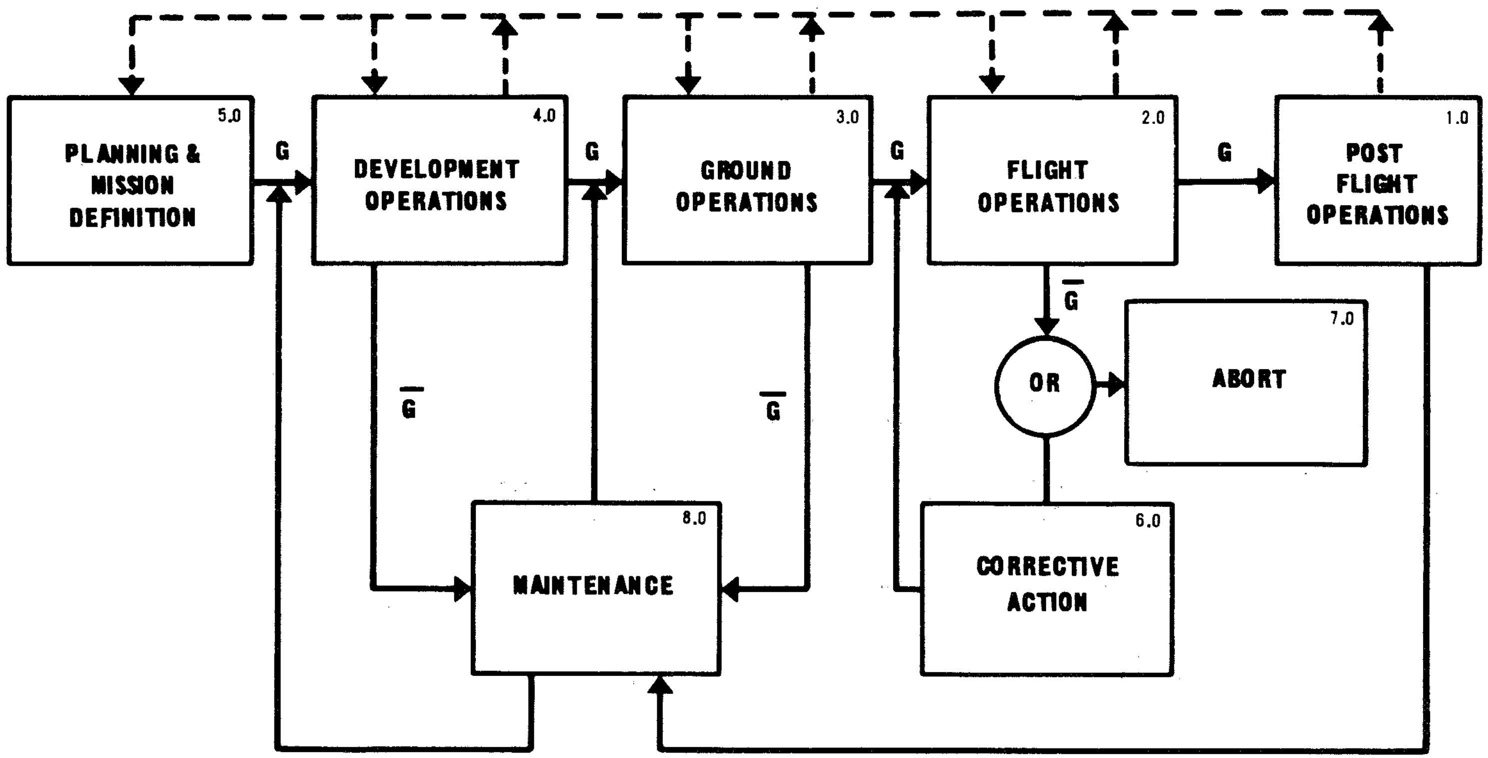

Figure 7. Top level functional diagram.

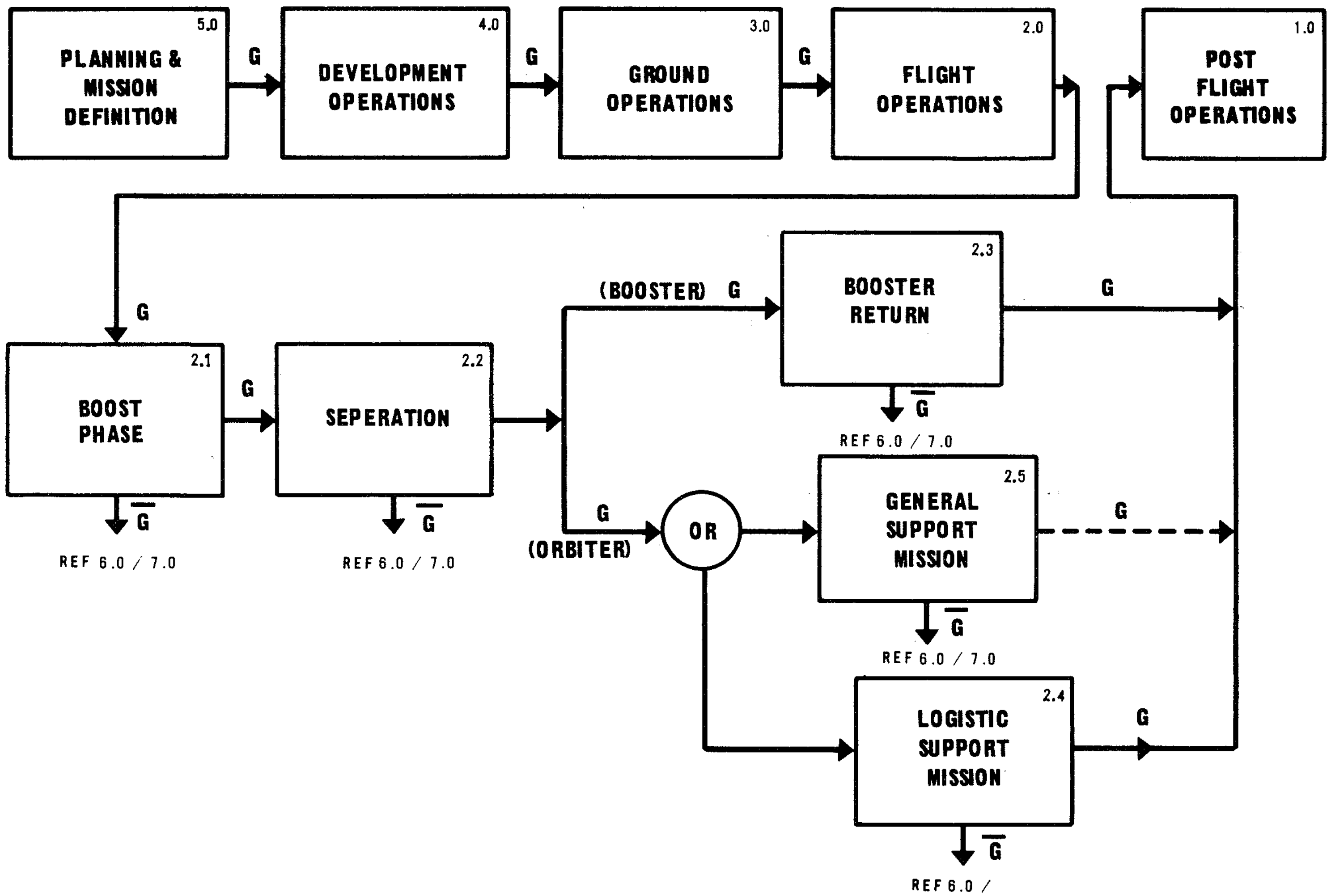

Figure 8. 2. 0 Flight operations.

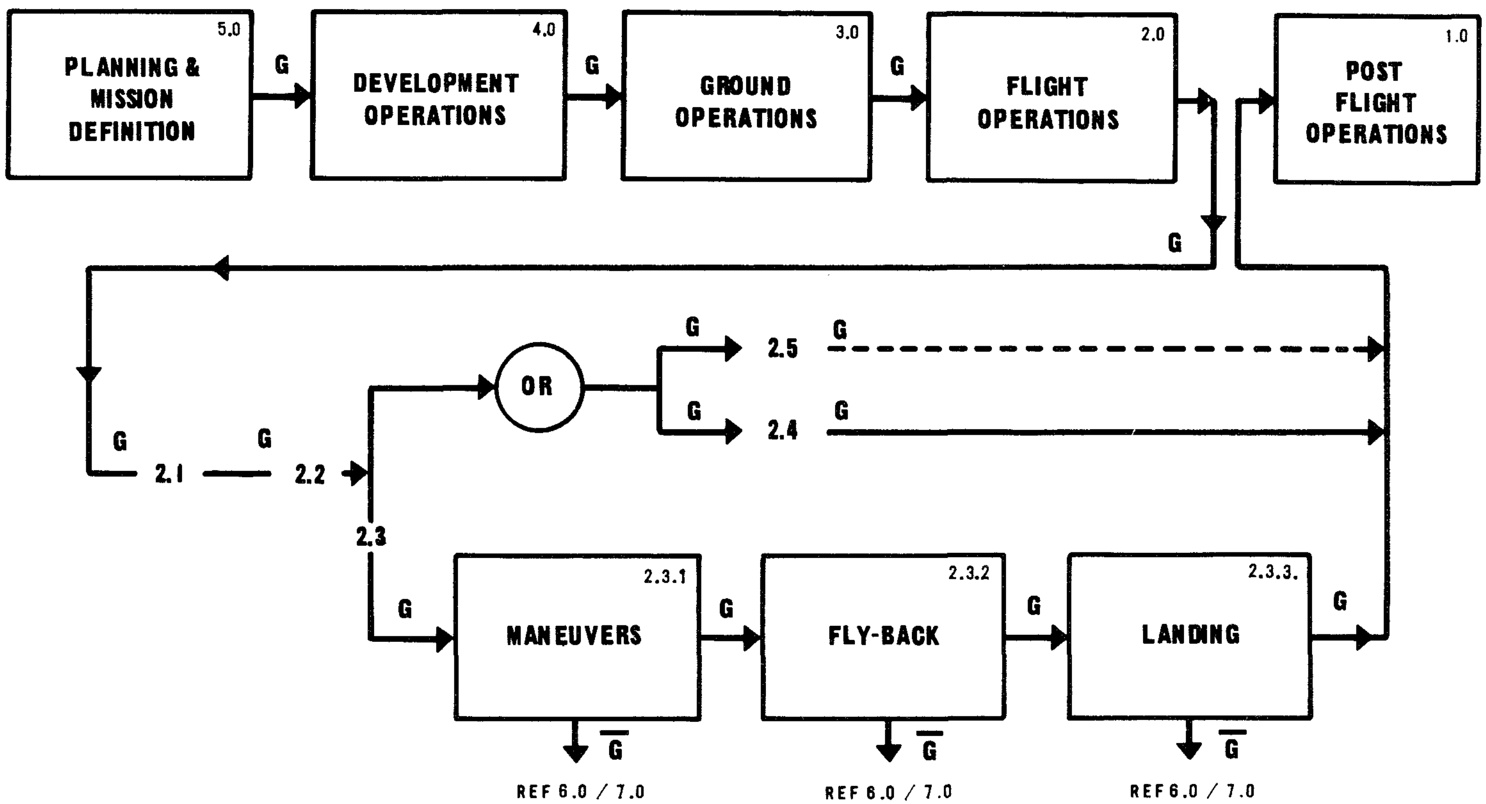

Figure 9. 2.3 Booster retur.

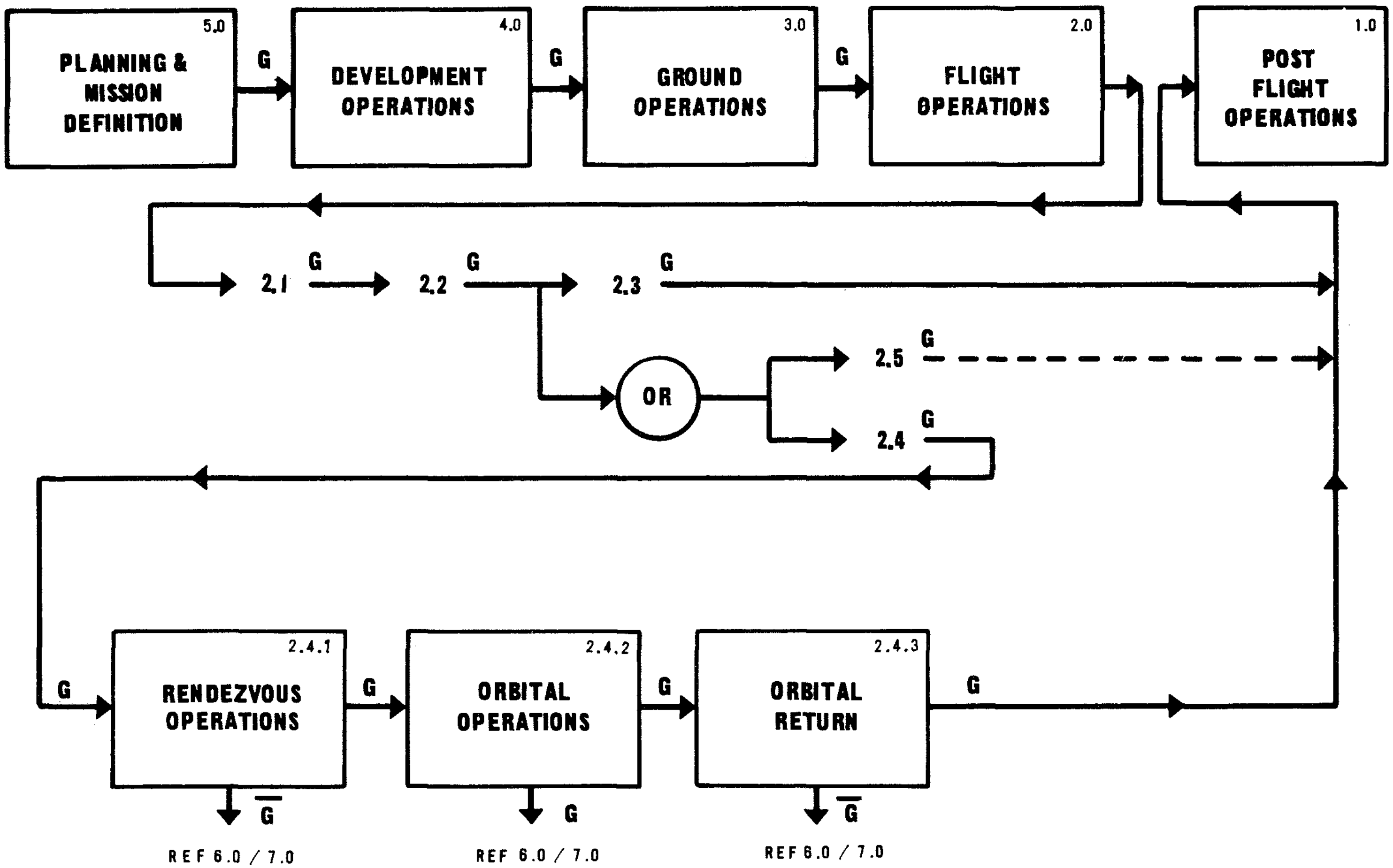

Figure 10. 2.4 Logistic support mission.

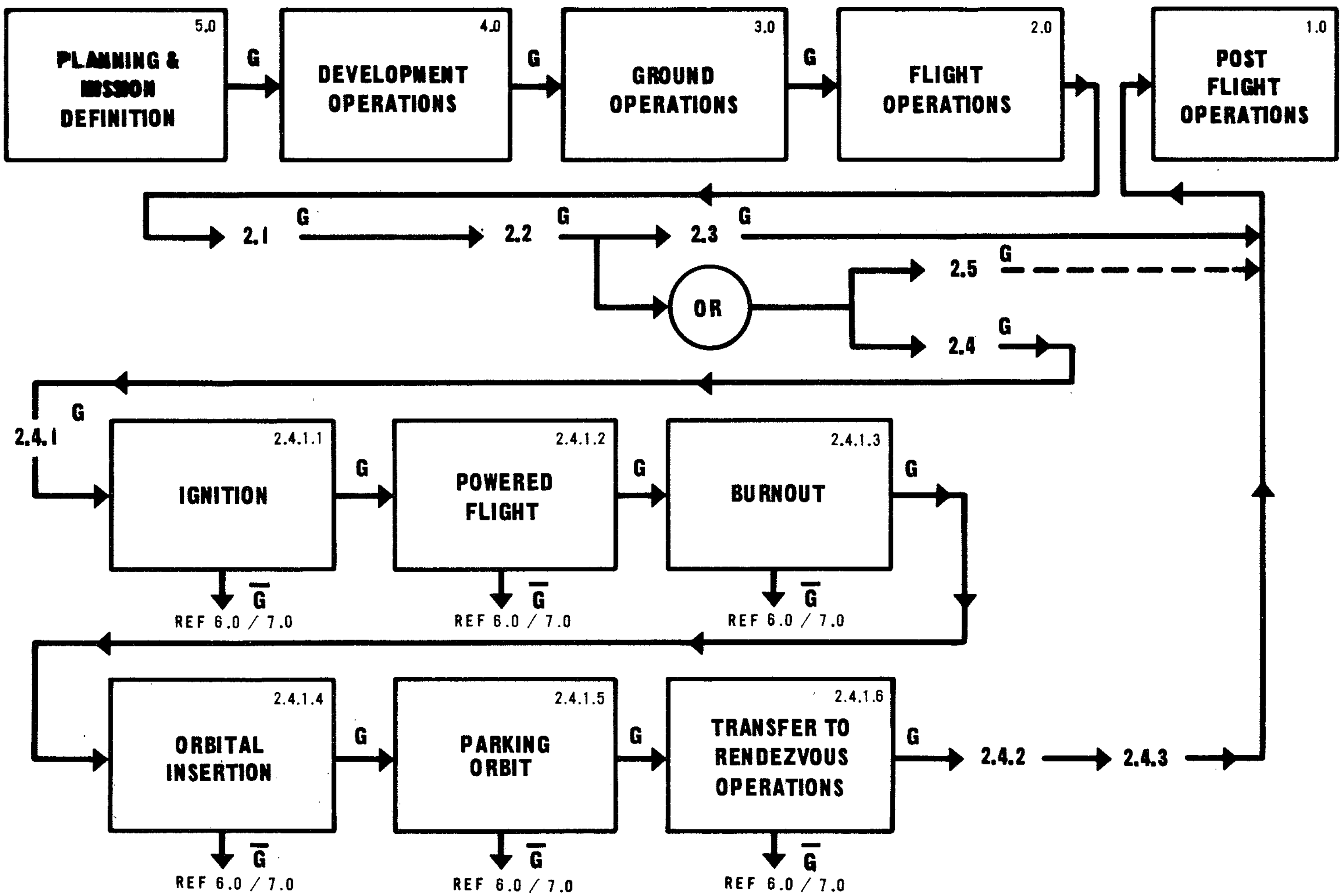

Figure 11. 2. 4. 1 Rendezvous operations.

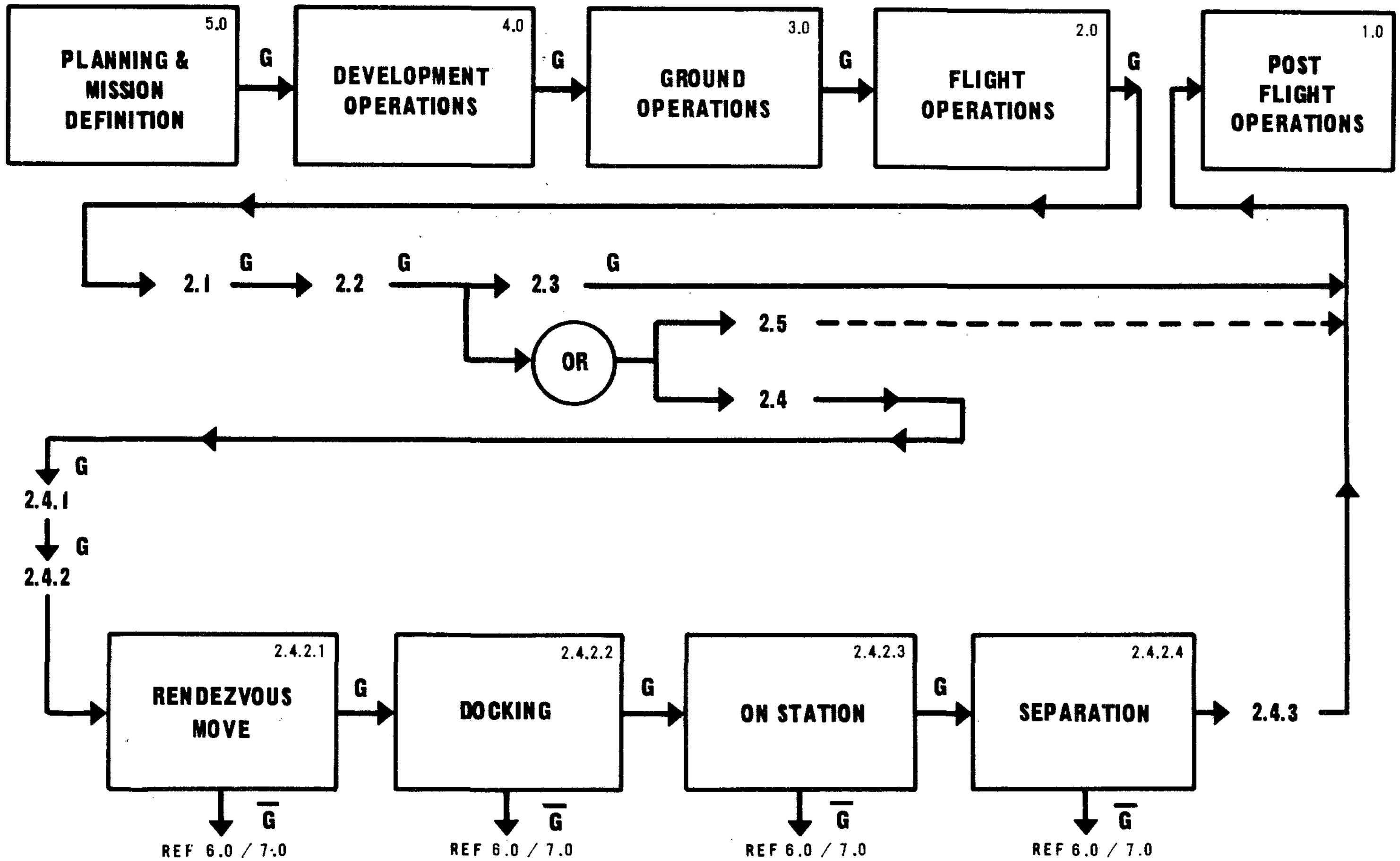

Figure 12. 2.4.2 Orbital operations.

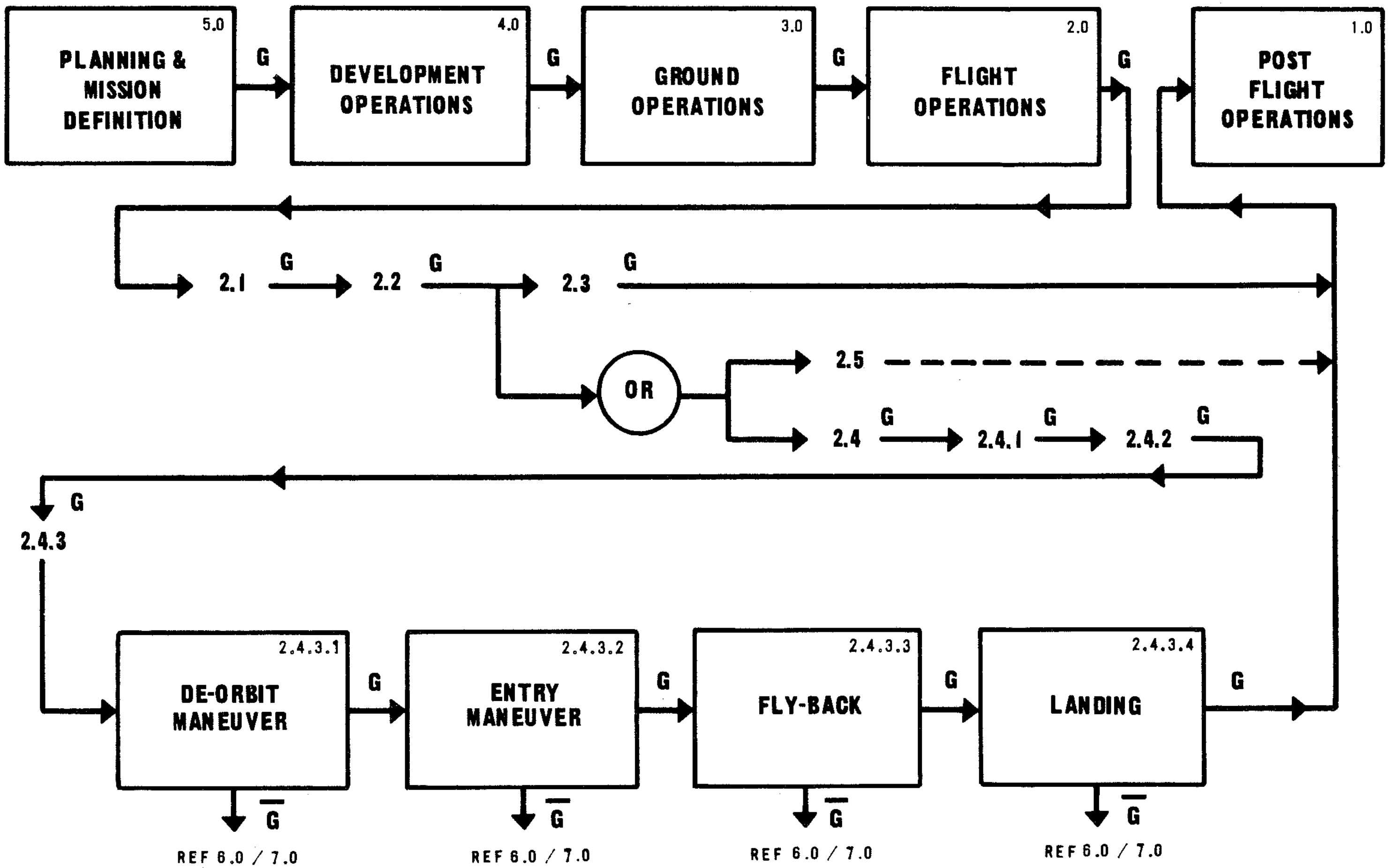

Figure 13. 2.4.3 Orbital return.

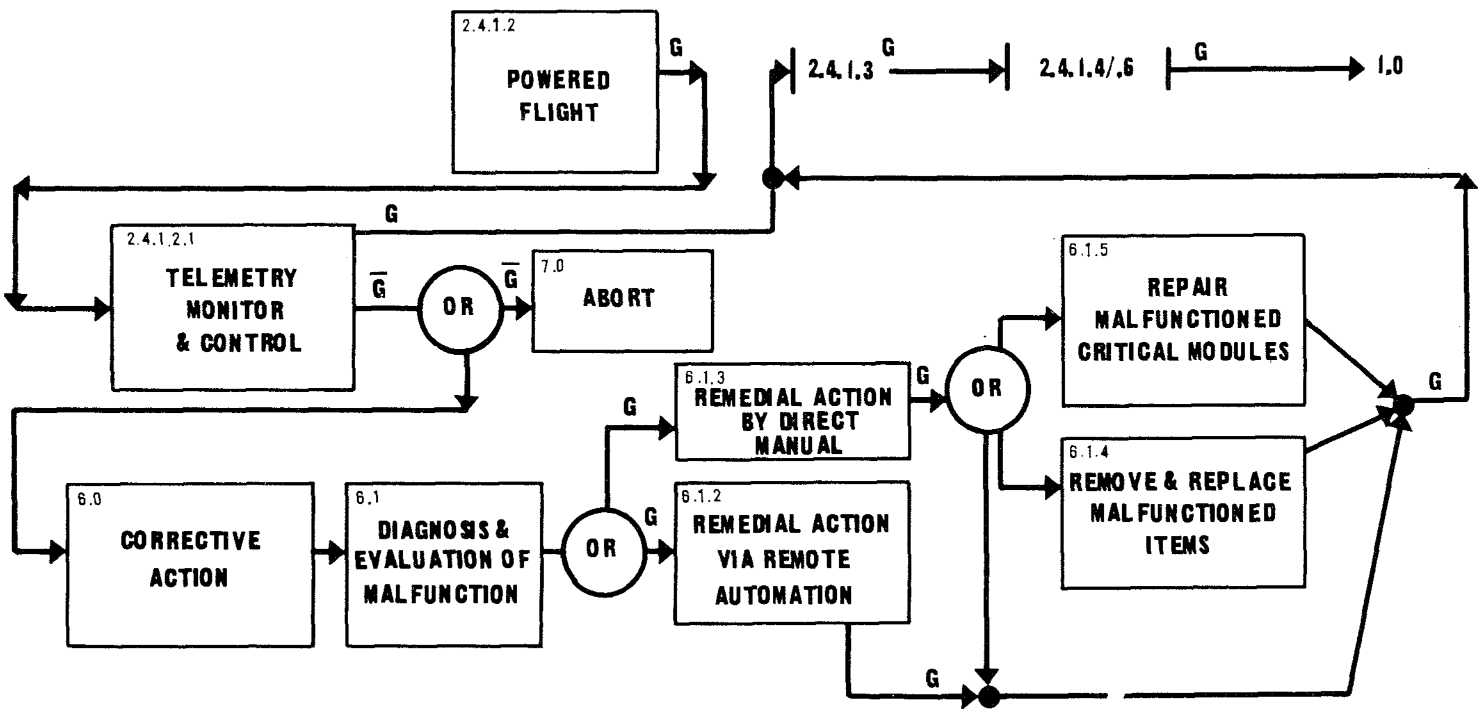

Figure 14. 6. 0 Fault isolation and correction.

END ITEM DESIGN FORM	NOMENCLATURE	TOP DWG NUMBER	PERFORMANCE SPEC NUMBER	DETAILED DESIGN SPEC NUMBER

INTEGRATED DESIGN REQUIREMENTS	FUNCTION BLOCK NUMBER	DESIGN CONFIGURATION

MSFC FORM 000

Figure 15. End Item Design form.

FUNCTIONAL ANALYSIS FORM		SUBSYSTEM						FUNCTIONAL FLOW DRAWING NUMBER
FUNCTION NAME & NO.	DESIGN REQUIREMENTS	END ITEM IDENTITY		PERSONNEL & TRAINING EQUIP REQMTS				TECHNICAL MANUAL & SPECS REQMTS
		NOMCL	DESIGN	TASK	TIME (HRS)	PERFORM	EQUIPMENT	

MSFC FORM 000

Figure 16. Functional Analysis form.

FUNCTIONAL ANALYSIS FORM	SUBSYSTEM: SEPARATION	FUNCTIONAL FLOW DWG NR 2.2.1

FUNCTION, NAME & NR.	DESIGN REQTS.	END ITEM IDENTITY		PERSONNEL & TRAINING REQTS				TECH MAN. SPEC. NR.
		NOMCL.	DESIGN	TASK	PERFOR.	EQUIP.	TIME	
RETRO-ROCKETS 2.2.1	PERFORMANCE: IGNITION THRUST: BUILDUP STEADY-STATE TAIL-OFF BURNING TIME INSTALLATION: ATTACHMENTS ALIGNMENT OPERATION: ELEC. NETWORK IGNITION VARIATIONS PHYSICAL CHECK LENGTH DIAMETER WEIGHT HANDLING, STORAGE & SHIPPING	ROCKET, RETRO XM 2.2.1 A 2.2.1 B 2.2.1 C ETC.	SOLID PROP MOTOR	INSTALL-ATION	FOUR HOURS	JIGS, WRENCHES ALIGNMENT THEO. BOLTS, ETC.	4 HOURS	SPEC. NR.: S.P. 2.2.1 A 2.2.1 B 2.2.1 C ETC. TECH. MANUAL T.M. 2.2.1 PROCEDURAL MANUAL P.M. 2.2.1

PERSONNEL IDENTIFICATION	
GOVERNMENT	CONTRACTOR
RESPONSIBLE PERSON J.P. JONES	RESPONSIBLE PERSON T.P. SMITH
ORGANIZATION MSFC-S&E-P	ORGANIZATION AMI-SD-P
TELEPHONE NUMBER 205/453-0012	TELEPHONE NUMBER 305/061-0367

Figure 17. Functional Analysis form (completed).

ELEMENT OF COST	AUSTERE	OPTIMUM	DESIRABLE
BOOSTER	$	$	$
ORBITER	$	$	$
GROUND SUPPORT EQUIPMENT	$	$	$
ENGINES	$	$	$
GROUND COMMUNICATIONS NETWORK (WORLD WIDE)	$	$	$
FACILITIES	$	$	$
SPECIAL TEST EQUIPMENT	$	$	$
PERSONNEL	$	$	$

Figure 18. Total program cost evaluation.

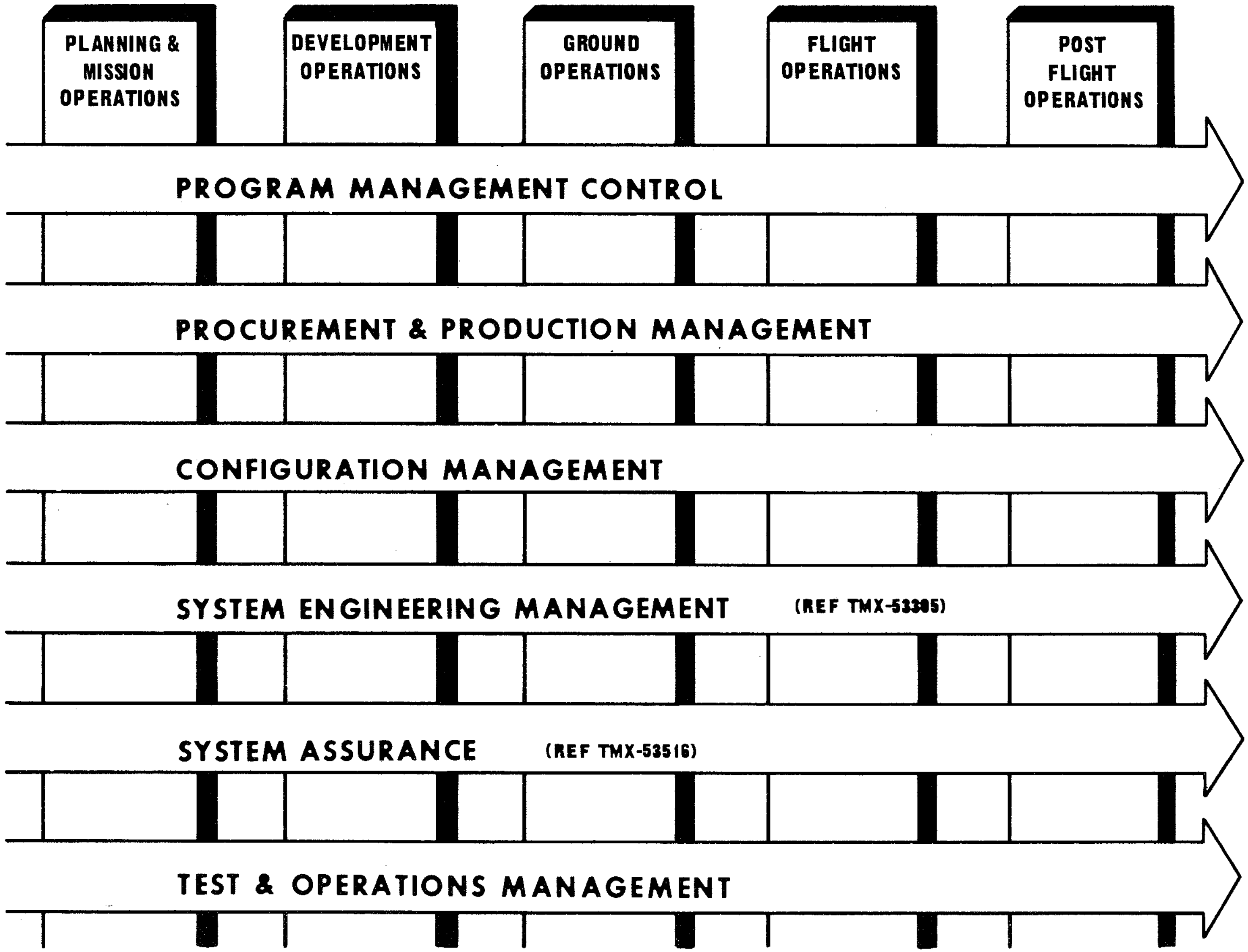

Figure 19. Management function in program elements.

APPROVAL

TM X-64537

JOINT ASSESSMENT AND MANAGEMENT EVALUATION SYSTEM

By Preston T. Farish and Richard J. Stein

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

PRESTON T. FARISH
Manager, Systems Safety and Manned
Flight Awareness Office

DISTRIBUTION

NASA TM X-64537

INTERNAL

DIR
DEP-T
AD-S
PM-SS (100)
A&TS-PAT
  Mr. L. D. Wofford, Jr.
PM-PR-M
A&TS-MS-H
A&TS-MS-IP (2)
A&TS-MS-IL (8)
A&TS-TU (6)

EXTERNAL

Scientific and Technical Information
  Facility (25)
P. O. Box 33
College Park, Maryland 20740
Attn: NASA Representative (S-AK/RKT)

MSFC—RSA, Ala